EPA

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MEMORANDUM

SUBJECT: Point of Compliance for Residential Soils Cleanup at Ruston/North Tacoma Superfund Site

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Attached for your review and comment is an issue paper on Point of Compliance for Soils. At the Ruston/North Tacoma Superfund site the remedy will most likely involve excavation of contaminated residential soils and replacement with "clean" soil. We will need to define the depth of excavation, and the thickness of a "clean" soil cap layer/barrier. I would like to get your perspectives on the basis or rationale for setting a point of compliance for soil cleanups in residential areas, i.e., what factors should be taken into consideration when determining or setting the thickness of a soil cap.

I have discussed this issue with project managers for the Bunker Hill site in Kellogg, Idaho, and the Smugglers Mountain site in Aspen, Colorado (both residential in nature). At these sites a point of compliance (or clean soil cap) of one foot has been established. The project managers stated that the basis for this decision was not technical in nature, but revolved around a "general feeling" that one foot would provide sufficient cover to be protective for most activities.

At a minimum, I would like to include a discussion of this issue (if not a specific point of compliance) in the Feasibility Study. Perhaps this is one of those issues that is more fully characterized during design. I would appreciate any suggestions you may have, as well as any other examples of how this issue has been approached at other sites. Your comments/suggestions will be most useful if I can receive them by January 11, 1991.

RUSTON/NORTH TACOMA SITE

POINT OF COMPLIANCE FOR SOILS:

ISSUES PAPER

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RUSTON/NORTH TACOMA SITE

POINT OF COMPLIANCE FOR SOILS:

ISSUES PAPER

<u>Purpose.</u> Surficial soils are the primary environmental medium in Ruston/North Tacoma that is residually contaminated from operations of the Tacoma Smelter. Should soil remedial actions be deemed necessary to reduce potential future exposures and risks to community residents and the environment, the point of compliance for such actions will have to be established. The point of compliance will define the depth below the post-remediation ground surface at which unremediated, residually contaminated soils at concentrations above cleanup levels (remedial action objectives) may remain. That point of compliance should be chosen to be adequately protective of potential contact with or releases from such residually contaminated soils. The purpose of this paper is to identify and discuss the issues associated with such evaluations leading to establishment of a point of compliance in soils for the Ruston/North Tacoma site.

There are two cases for which determination of a point of compliance is moot. First, no point of compliance is needed if a determination is reached that remedial actions are unnecessary, that is, that existing and projected future levels of soil contamination do not pose unacceptable risks to human health or the environment. Second, no point of compliance determination is needed if a decision is made to remediate all soils, at whatever depths they may occur, that exceed selected cleanup levels; such a "total remediation" alternative establishes, in effect, a point of compliance as deep as the deepest contamination exceeding cleanup levels. By eliminating any residual contamination above the cleanup levels, a total remediation alternative would obviously be protective of future unacceptable exposures or releases. In all other cases, residually contaminated soils that exceed cleanup levels would have to be considered in establishing a point of compliance.

<u>Introduction.</u> By treating or excavating and replacing with clean soils a layer of contaminated surface soils down to the point of compliance, remedial actions will create a containment or barrier to further exposures or releases

from deeper, unremediated soils. Evaluating a suitable point of compliance is equivalent to assessing the long-term effectiveness of a containment/barrier of a given thickness in adequately controlling potential future exposures and releases of contaminants. Thus, an evaluation of potential "failure modes" of containment is necessary for evaluation of a point of compliance. [Other factors related to the depth of soils remediated, such as total remediation costs and risks or other negative impacts imposed by taking the remedial actions themselves, may also be considered in selecting a point of compliance. However, the discussions here are limited to the issues related to the effectiveness and long-term protectiveness of the point of compliance for soils].

These evaluations assume that, in order to maintain grades in residential areas subject to remediation, the depth of any excavated materials is equal to the depth of replacement soils used to backfill remediation sites. It is also assumed that the containment/barrier above unremediated soils consists solely of treated or backfilled soils, without additional engineering features (e.g., infiltration barriers, gas migration controls, erosion barriers). Remediated sites are assumed to be revegetated; however, the long-term maintenance of a good vegetative cover may require some institutional or maintenance controls, whose long-term effectiveness is therefore of concern.

Several kinds of actions or processes could lead to exposures or releases of contaminants from unremediated soils below the containment/barrier layer. For the purposes of this paper, actions that could lead to failure of containment are grouped into the following categories:

- physical degradation of the cap
- intentional actions of residents
- unintentional actions
- other actions or processes that could result in contaminant migration or transfer without physical degradation of the cap

Each of these failure mode categories is discussed separately below, with specific actions or processes identified within the categories. It should be noted that although they are discussed separately, different types of actions could interact to produce exposures or releases. For example, physical erosion processes could result in thinning, but not a breach, of the cap; subsequent activities such as regrading or landscaping could then penetrate the thinned cap, where they would not have penetrated the original full-thickness cap. The cumulative, interactive effects of all of the actions discussed below are relevant to the evaluation of the point of compliance.

The primary issue to consider in evaluating the point of compliance is how possible failures of containment, with consequent exposures or releases of contaminants, could vary as a function of the thickness of the cap (depth to unremediated soils above the cleanup levels). A number of factors are relevant in considering any single failure mode. These include: the probability of occurrence; the degree of failure (severity); mitigation potential, including effective mitigation actions and whether failure occurs suddenly or gradually, with warning signs; and the consequences of failure, including duration, spatial extent, and frequency of potential exposures, and contaminant concentrations.

The time period of interest for evaluating the performance of the cap in providing adequate containment may be defined by that period during which contaminant concentrations in unremediated soils below the cap remain above cleanup levels. Since natural processes that reduce soil concentrations of arsenic and lead, as well as other metals, are probably very slow, the time period of interest from this perspective is indefinitely long. A preliminary evaluation time frame of about 30 to 100 years may be useful to consider from the point of view of effective institutional controls, as well as based on a risk assessment exposure period for carcinogenic risks.

Considering all of the potential modes of containment failure, their probabilities, consequences, and potential for successful mitigation, a point of compliance should be selected to provide acceptable probabilities of specified levels of potential exposures (risks) or releases. Selection of a point of compliance therefore involves risk management decisions. Potential exposures above cleanup levels may be deemed acceptable at some non-zero probability of occurrence, provided that the spatial extent or duration of exposures is limited. A zero probability of such exposures or releases may not be justified from a risk management perspective and may result in an unnecessarily restrictive point of compliance.

The potential for successfully preventing or recovering from identified potential failures of containment is important for a risk management decision. Such mitigation affects the probability of occurrence and the consequences of the types of containment failures discussed here. The design of remedial measures may contribute to such mitigation of potential cap failures, but institutional controls are probably even more important. Institutional control and mitigation issues are being addressed separately by EPA, Region 10 and ICF/Clement (Ingrum, 1990). The results of those evaluations should be combined with the discussions in this paper for evaluation of the point of compliance for Ruston/North Tacoma soils.

<u>Physical Degradation.</u> The most important natural process that could physically degrade the cap is stormwater erosion. Other conceivable processes - wind erosion, freeze/thaw cycles - could occur but are expected to have

limited importance in comparison to stormwater erosion. Mass erosion from the cap could result in an overall thinning of the cap as well as preferential losses in rills or gullies that would develop progressively, leading to initial potential exposures on specific, limited portions of the capped site.

An initial evaluation of potential erosion was performed using the Universal Soil Loss Equation (Bechtel, 1990a and 1990b). For relatively flat and well-vegetated sites, no erosion losses of consequence were projected. Assuming a slope length of 75 feet (representative of typical parcel sizes in Ruston/North Tacoma) and the absence of any effective vegetative cover, mass soil losses in tons per acre per year were calculated for slopes varying from 4 to 16 percent. These calculations represent worst case conditions. Soil losses ranged from 2.52 to 17.5 tons per acre per year as slopes increased from 4 to 16 percent. Further assuming a uniform loss over the entire parcel, erosion losses were calculated as follows:

SLOPE	INCHES/YR	YEARS TO TOTALLY ERODE A CAP OF:		
		3 INCHES	6 INCHES	12 INCHES
4%	.0126	238	475	950
8%	.0302	99	199	398
12%	.0561	53	107	214
16%	.0877	34	68	137

If moderate vegetative cover (including unmaintained, weed-covered lots) rather than barren slopes existed, the mass erosion could be reduced by one-half or more, and the years to total loss of cap would be at least doubled. A well-maintained grass cover would likely decrease soil losses and increase times to loss of cap by a factor of 30 (Bechtel, 1990b).

The assumption of a uniform lowering of the soil surface is unrealistic in not accounting for rill erosion. A simple "conservation of mass" model of rill erosion was used to evaluate its possible significance for the performance of a soil cap. This model includes assumptions about the spatial frequency of rills (inter-rill distances), their cross-sectional shape and area, and the rill fraction of total soil loss predicted from the Universal Soil Loss Equation (which is a function of slope, among other things) to estimate rill depths as a function of slope and the number of years of erosion (Glass, 1990a, 1990b). This model was then used to assess a large number of combinations of the variables describing rill erosion, calculating for each one the percentage of total soil mass erosion that would be required from rills to result in specified rill depths in a specified number of years. Resulting percentages less than 100 percent reflect conceptually possible rill development scenarios under the model, with probabilities of occurrence of rills at least as severe as modeled (i.e., greater than or equal to the depth indicated within the period specified) increasing as the calculated percentage decreases. The Universal Soil Loss Equation is in fact based on erosion that is assumed to largely be due to rill development (Bechtel, 1990b).

The different assumptions made for variables characterizing rill development result in widely varying results for the speed of development of rills of any specified depth (cap penetration). Rill depths of 0.5 feet or more within only a few years are possible under some modeled scenarios. Several of the ERA sites in Ruston/North Tacoma, which were capped within the last year, were in fact showing some rill erosion by the Fall of 1990. Field observations of those sites were used to suggest the most reasonable cases from among the large number of modeled scenarios (Johnson, 1990). Assuming for simplicity that rill frequencies and cross-sectional areas (shapes) do not vary significantly as a function of slope steepness, the results for ERA sites with slopes of about 4 to 8 percent were used to estimate results for the range of 4 to 16 percent slopes. The results can be summarized as the number of years to develop specified rill depths if all of the soil mass erosion came from rills (limiting case). The results would be multiplied by 1/p, where p is the fraction (0 to 1.00) of total soil erosion from rills, for lesser rill contributions. General rill modeling results for the limiting case based on approximately 12-foot spacing between rills are as follows (from Glass, 1990b):

SLOPE	YEARS (LIMITING CASE) TO DEVELOP RILL DEPTH OF:		
	3 INCHES	6 INCHES	12 INCHES
4%	3 to 6	12 to 24	48 to 95
8%	1 to 3	5 to 10	20 to 40
12%	0.7 to 1.3	3 to 5	11 to 21
16%	0.4 to 0.9	2 to 3	7 to 14

Note: from the rill modeling equation, the years to develop rill depths of 6 and 12 inches are 4 and 16 times, respectively, the years to develop 3 inch rills for a fixed scenario of rill development. Values shown above are rounded.

Closer rill spacing or wider, shallower rill cross-sections would increase the years required to develop rills of a specified depth. Increasing vegetative cover that resulted in less soil mass erosion would similarly increase the time required to develop rills of a specified depth. Erosion losses from non-rill portions of a site, as estimated from the Universal Soil Loss Equation, will be smaller and slower as rill losses increase.

The field observations of ERA sites were made after a relatively wet Fall on sites where recent hydroseeding had not yet developed a thick grass cover.

Intensive precipitation in the following week, including record 24-hour rainfall, led to a very rapid deepening of the existing rills on one site with a slope of about 5 percent (from 1 inch to more than 4 inches, sufficient to penetrate the topsoil cover and expose bank run gravel sub-base materials)(Corbett, 1990). This indicates the potential for extreme events to markedly accelerate the estimated rill erosion depths as calculated in the rill model and summarized above.

Additional technical information on rill development and models may be available in the geomorphology and agricultural engineering literature.

The development of rills that penetrate the cap could mobilize residual contamination from beneath the cap via surface runoff, and potentially even by wind resuspension. Direct contact exposures to deeper, contaminated soils would be limited to the relatively small portion of a lot developing rills (which could be attractive to children playing at the site) or to other locations of contaminant transport from the rills.

<u>Intentional Actions.</u> The term intentional actions as used here refers to a variety of actions that may be taken by or on behalf of a property owner or resident to achieve a specific intended result. Intentional actions can include the following:

- building construction, excavation (e.g., foundations)
- regrading and landscaping
- planting (trees, ornamentals)
- gardening
- utility line installation, repair, or removal (including water, sewer, gas, oil, electric, or communications lines)
- underground tank installation or removal (e.g., home heating oil tank)
- resodding, tilling, paving, or maintaining yard soils

The probability of these actions taking place at a given site, or the frequency with which they could occur, varies significantly. A substantial percentage of residents may have home gardening areas in any given year, perhaps moving in location within a lot from year to year. Regrading or significant landscaping changes may occur much less frequently, perhaps becoming more likely at the time of a property purchase (national average residence times are cited at about 10 years in EPA RAGS guidance document).

Substantial utility line actions or tank installation/removal at existing properties may be even less frequent. New construction or renovations at existing properties that would result in soil excavation are influenced by housing market conditions and may undergo periods of heightened activity.

Different intentional actions would vary in their depth of disturbance of surficial soils. Resodding of an existing lawn may require preparation of the site to a depth of about one-half foot, while gardening would probably disturb existing soils to a maximum tilling depth approaching one foot. New plantings and site regrading could commonly extend somewhat deeper. Utility line actions may have their depths determined more by site grade than by depths required to avoid freezing temperatures. Tank installation/removal or excavations associated with construction or renovation would be expected to require the deepest disturbances of existing soils.

The size of disturbed areas would also vary among intentional actions. A single tree planting, for example, might require digging over only a few square feet. A utility line action could require on the order of 50 to 100 square feet, while an excavation for a structural addition might require several hundred square feet of soil disturbance. Substantial regrading or landscaping of a lot could involve disturbance of a large portion of the lot's soil cover. Excavated or disturbed soils from some depth below the surface could be spread over the surface of the parcel as a result of intentional actions, or they could largely be replaced in excavations (with some depth mixing of materials). In some cases, excavated materials could be taken offsite for disposal or use at other sites, where they could pose some risks of exposures to other populations. The fate of excavated materials, and particularly the degree to which they remain on the surface of a parcel after completion of the activity, affects the potential for long-term exposures.

Intentional actions that could disturb a soil cap characteristically have a short, defined period during which they occur. They may, however, occur repeatedly. Some actions of this type will have prior notification (e.g., permitting requirements); others will occur at the discretion of a property owner without notification. In contrast to progressive physical degradation of a cap, intentional actions proceed to disturbance very rapidly.

Gardening or regrading actions are likely to result in mixing of soils, reducing somewhat the concentrations of any disturbed unremediated soils below the cap. Other actions, especially excavation of discrete areas of soils for various reasons, may result in little or no mixing and dilution of contaminant concentrations. Some possibility of air releases of contaminated particulate matter exists with most intentional soil disturbances; if unmitigated, this could result in short-term inhalation exposures and deposition of particulate fallout over a wider area, recontaminating surface soils. However, the exposure pathway of most concern would be long-term ingestion exposure to contaminants reintroduced to surficial soils as a result of disturbance of the cap.

<u>Unintentional Actions.</u> Unintentional actions are those not associated with any directed or anticipated outcome by residents. They may frequently occur without awareness of a property owner or resident, at least initially. Unintentional actions include the following:

- children's play activities
- pets digging in yards
- burrowing animals

The probability of soil disturbance by children's play activities or digging by pets is quite high; these actions are expected to occur with high frequency where children or pets reside, varying only in degree. There is probably a primary age range (perhaps from about 4 to 12) for children when digging is most frequent and most vigorous. The degree of such activity may also be influenced by the degree of parental supervision of outdoor play and parental attitudes toward such actions that affect yard appearance. Burrowing animals in urban residential neighborhoods also can occur, primarily at a frequency determined by the suitability of the environs as habitat.

The depths to which soils may be disturbed by unintentional actions probably depends on both the nature of the actions themselves and the time until their discovery by residents, with possible actions being taken after discovery to mitigate, limit, or control them. The same may be true for the spatial extent of soil disturbance. Children's play activities and digging by pets may have a decreasing probability of disturbing soils at greater depths, with a high probability of disturbance down to about 6 inches and a practical limit (small probability) at between 1 and 2 feet. The size of affected areas would typically be small (no more than 10 or 20 square feet), becoming larger only when disturbance was undiscovered for longer periods or well-tolerated by property owners. Uncontrolled burrowing animals could produce larger areas of soil disturbance.

In contrast to intentional actions, unintentional actions could occur at any time and over extended periods of time. Soil disturbance would be progressive as long as the activity continued, much like physical degradation of the cap.

The primary exposure concern would be long-term ingestion of contaminated soils from below the cap that are reintroduced to the surficial soils in the yard. It is likely that most disturbed soils would end up being broadcast over surface areas of the yard by unintentional actions such as those identified here. Direct contact by children during the disturbing activities could also result in elevated soil contact rates for a short time period (as a function of the nature of the activities), resulting in increased contaminant intake.

<u>Nondisturbance Issues.</u> Potential exposures or releases of contaminants from soils beneath the cap could occur without disturbance of the cap itself. Infiltration of precipitation and leaching of contaminants to ground water has been determined to be an insignificant pathway for contaminant migration at this site. Two other mechanisms for migration of contaminants have been identified:

- root zone vegetation uptake, decomposition

- methylation and volatilization

Uptake of contaminants from deeper, residually contaminated soils into vegetation can occur if the root zone of the vegetation extends to depths below the cap (or if worms or other fauna mix contaminants up into cap materials). Root zone depths may vary from a few inches for grass to several feet for larger ornamental shrubs or trees; garden crops may similarly show variation to typical depths of about one foot. Uptake factors for specific contaminants to specific types of vegetation would limit contaminant migration by this pathway. If above ground leafy matter accumulates contaminants, its decomposition could reintroduce contamination to surficial soils and thereby increase long-term exposure potential. Consumption of garden crops that accumulate contaminants from soils below the cap could contribute to ongoing contaminant exposures and risks. For arsenic, the potential uptake into vegetation is probably not of major concern.

Biological methylation of soil inorganic arsenic and subsequent volatilization and release to air has been identified as a potentially significant fate process (refer to SAIC fate discussion). Such a volatilization process may contribute to ambient air arsenic concentrations, including particulate concentrations. The efficiency of soil arsenic volatilization and release as a function of depth is not well characterized. It is possible that a soil cap could substantially reduce or eliminate volatilization losses of arsenic from deeper soils, and that even a 3 inch cap could be effective in achieving such reductions. However, a more detailed evaluation of the relationship of volatilization losses to the depth of the cap is not possible without additional information. Recontamination of surficial soils from deposition/fallout of ambient particulates with arsenic derived from soil volatilization losses is probably too small to be of consequence for long-term exposures. The primary exposure of concern related to soil volatilization losses would be long-term inhalation exposures; that is, the issue is the long-term elevation of ambient arsenic concentrations above background due to soil arsenic volatilization.

Another potential nondisturbance issue is recontamination of surficial cap materials. This could most likely occur from demolition activities or other site remediation of the Tacoma Smelter site, or from site runon or particulate deposition from adjacent or nearby unremediated sites in Ruston/North Tacoma. Any of the actions discussed previously that could disturb a soil cap and expose deeper unremediated soils could also result in mobilization of contaminants from one site to adjacent sites. For example, physical degradation (erosion) of a cap on a steeply sloped site could result in recontamination of the surface of a cap on a flat parcel downgradient from the first site, even though erosion and other actions did not disturb the cap on the flat site.

<u>Additional Considerations.</u> Proposed cleanup standards issued by the Washington Department of Ecology (Chapter 173-340 WAC, July 27, 1990) to implement the Model Toxics Control Act include a discussion of the point of compliance (depth) for soil cleanup actions. In residential areas and in cases where soil cleanup is not being performed to protect ground water, a minimum point of compliance of one foot is established, and a presumptive point of compliance of 15 feet is identified. The latter 15 foot depth is based on an assumed maximum depth of disturbance from site development activities. Factors that can be considered on a site-specific basis to reduce the 15 foot deep point of compliance are identified in WAC 173-340-740(6)(e). Ecology may revise these proposed rules in response to public comments before final rule issuance, which is expected by early 1991.

A deeper point of compliance would affect the extent, and could affect the nature, of remedial actions. As a result, the short-term risks posed by taking remedial actions could be increased. For example, risks of breaking utility lines during soil excavation and replacement increase as the depth of excavation increases, and impacts associated with transporting soils (including traffic injuries and fatalities) increase as the volume of materials excavated and hauled increases. Such increased risks and impacts should be balanced against the increased effectiveness and protectiveness of thicker soil caps in assessing the point of compliance. The possibility of combining institutional controls with physical remediation measures should also be evaluated.

The point of compliance has so far been discussed as though it was necessarily identical for all sites to be remediated. That does not have to be the case. The point of compliance could be allowed to vary among properties as a result of identifiable characteristics. For example, since long-term exposures and risks resulting from cap disturbance are expected to vary depending on the contaminant concentrations in soils beneath the cap, the cap thickness could be made to depend on the degree and spatial extent of residual contamination at depth. Similarly, soil cap thickness could be increased as slope steepness increases to protect against potentially higher and faster soil erosion. Other factors may also be used to vary the point of compliance on a site-specific basis.

<u>Summary.</u> Determination of the point of compliance requires an assessment of the depth of soil remediation that is adequately protective of potential contact with or releases from contaminated soils remaining below a soil cap. The various possible failure modes of soil cap containment of deeper soil contamination require evaluation. Failure modes involve different types of actions or processes that could result in exposures or releases from soils below the cap. They may be generally categorized into the following four groups:

- physical degradation of the cap
- intentional actions of residents
- unintentional actions
- nondisturbance contaminant release processes

The actions and processes that could lead to failure of containment by the soil cap are each characterized by a number of factors: their probability and frequency of occurrence; the degree of failure (severity); mitigation potential, including effective mitigation actions and whether failure occurs suddenly or gradually, with warning signs; and the consequences of failure, including duration, spatial extent, and frequency of potential exposures. The contaminant concentrations for potential exposures resulting from a failure of containment reflect both the site-specific degree of contamination in soils beneath the soil cap and the action or process creating the potential for exposure (e.g., the degree of mixing and dilution of contaminants involved in the action).

The risks of exposures or releases associated with any specified point of compliance (depth of soil cap) reflect the cumulative and interactive effects of all failure modes. In general, those risks decrease as the depth for compliance with cleanup criteria increases. Selection of a soil point of compliance (or multiple points of compliance as a function of specified site-specific features) is a risk management decision that should be based on definition of an acceptable probability of a specified level of potential exposure or release of contaminants from soils beneath the cap. Increased costs for remediation and increased short-term impacts and risks associated with taking remedial actions may also be considered in this risk management decision.